EXECUTIVE SUMMARY

ABSTRACT

During July 1988, the U.S. Geological Survey began a Remedial Investigation (RI) of contamination at Operable Unit 4 (OU 4) at Hill Air Force Base (AFB). OU 4 includes landfills 1 and 2, the north gate dump sites, munitions dump, and spoils area. The objectives of the RI were to (1) characterize the extent of contamination; (2) determine the fate of contaminants; and (3) develop a baseline risk assessment for the potential exposure pathways through soil, ground water, and air. James M. Montgomery, Consulting Engineers, Inc. (JMM) conducted risk assessment studies during June 1989-91, working under a contract with Hill AFB. The Draft Baseline Risk Assessment for OU 4 is presented in Volume 2, dated November 1991.

The landfills at OU 4 are located along the top of a steep, terraced, north-facing escarpment that separates the Weber Delta from the Weber River valley. Landfill 1 covers about 5 acres and is located in the northeastern part of Hill AFB. Landfill 2 covers about 4 acres and is located about 900 ft northwest of landfill 1.

Previously suspected source areas of the TCE contamination, referred to collectively as the north gate dump areas, are located along Foulois Drive southeast of the north gate and along the Hill AFB boundary northeast of Foulois Drive. There is no documentation of dumping at these sites, but it has been alleged that drums containing solvents and other material were disposed of during unauthorized dumping episodes at several sites along Perimeter Road (Radian Corp., 1990, p. 1-4). The munitions dump is located about 400 ft southwest of landfill 1 and the spoils area about 700 ft to 1,000 ft east of landfill 1.

The southwesternmost (upgradient) occurrence of TCE was in water from wells located along the downgradient edge (north side) of landfill 1. Because no TCE was detected upgradient from landfill 1 the most probable source of TCE for OU 4 is landfill 1.

Evaluations of data collected during 1992 confirmed that landfill 2 and the munitions dump were not source areas of TCE or other contaminants. Extensive analytical tests were done in the previously suspected north gate dump areas to determine if contaminants other than TCE were present in the sediments of the unsaturated zone. In this report, all soil and sediment samples collected at OU 4 are referred to as sediment samples. Only trace concentrations of two herbicides were found. Concentration gradients of TCE in the unsaturated zone in these areas suggest that the TCE was derived from contaminated ground water that has migrated downgradient from landfill 1; thus, the north gate dump areas are no longer suspected of being source areas of the TCE contamination.

Hill AFB overlies three aquifers. Two of the aquifers, the Sunset and the Delta, are productive sources of good-quality water and are used by both Hill AFB and surrounding communities. Water in these aquifers generally is confined and occurs at depths of 300 and 600 ft below the landfills. Shallow ground water, in which contamination has been detected, overlies the Sunset and Delta aquifers. Based on the ground-water classification criteria of the State of Utah and the chemical quality of ground water from uncontaminated wells in the shallow aquifer of OU 4, the ground water would be classified as "Drinking Water Quality," Class II (Dept. of Environmental Quality, written commun., August 21, 1991).

During 1986-92, 13 volatile organic compounds (VOCs) and 2 inorganic contaminants were detected in shallow ground water from monitoring wells and seeps in the area of OU 4. TCE was detected most frequently and in the highest concentrations.

TCE exceeded the maximum contaminant level (MCL) in water from 20 monitoring wells and 3 seeps; benzene exceeded the MCL in water from 1 well; and 1,2-DCA, xylenes, sulfate, nitrate, and fluoride were detected but did not exceed the MCLs in water from any of the wells or seeps. No semivolatile organic compounds, organochlorine pesticides, or PCBs, chlorinated herbicides, or petroleum hydrocarbons were detected in the samples. Arsenic exceeded the MCLs in water from two wells, nickel in water from two wells, and selenium in water from one well.

The largest concentration of TCE outside the Hill AFB boundary extends north from well LF1GS6. A tongue of the plume containing between 1,000 and 5,000 ug/L extends about 1,000 ft from well LF1GS6, downgradient to South Weber Drive. Inside the boundary of Hill AFB, the maximum concentration of TCE in ground water was 18,000 µg/L, and outside the boundary, the maximum was 2,800 µg/L. The contaminated area inside the boundary of Hill AFB is about 18.5 acres, and outside the boundary it is about 44 acres. OU 4 includes landfills 1 and 2, the north gate dump sites, munitions dump, and spoils area.

About 87 percent of the TCE in the water fraction of the subsurface is present in water with a TCE concentration that exceeds 1,000 µg/L and represents about 34 percent of the total volume of contaminated water. The total weight of the TCE in the contaminated water is about 1,400 lbs, or about 113 gal of pure TCE product. If equilibrium conditions exist, then 240 gal of TCE are sorbed to the contaminated soil fraction of the subsurface. The total volume of TCE in the subsurface was computed to be 353 gal.

Data available as of November 1991 did not indicate that there were any complete exposure pathways that presented any significant health risk to people living or working in the vicinity of OU4; however, more data need to be collected to adequately determine the risk associated with inhaling indoor air. The data also indicated that there was little potential for ecological harm to result from the contaminants present at OU4. Human health risk associated with the occurrence of TCE, however, could develop in the future. TCE concentrations in the shallow ground water are high near the source area at Hill AFB and near the Cutler residence, and could present a potential health risk should someone use this water for general domestic purposes such as drinking and showering.

INTRODUCTION

The Final RI report for OU 4 (vol. 1, June 1992) contained recommendations for additional work needed to complete the RI investigation. In February 1992, an addendum workplan was approved by the State of Utah and the Environmental Protection Agency (Jason Knowlton, Utah Division of Environmental Health, and R.F. Stites, U.S. Environmental Protection Agency, written commun., 1992) for the additional field activities necessitated by those recommendations.

During March - August 1992, field activities were carried out according to the workplan. Some modifications were made to the plans based on findings during the field activities.

The purpose of this report is to confirm or revise the Final RI (vol. 1) based on the results of the additional work done during March - August 1992. For convenience, the sections of this report are numbered the same as the sections in the Final RI report. The summary and conclusions and the Executive Summary of the Final RI report (vol. 1) have been revised as appropriate to the findings discussed in this report (vol. 11) and are presented as complete sections. The remainder of the addendum report only updates specific sections where new data have confirmed the prior findings or revisions have been made.

The U.S. Air Force (USAF), in performing its primary mission of defense of the United States, has frequently engaged in operations that deal with toxic and hazardous materials. The Department of Defense (DOD) has implemented the Installation Restoration Program (IRP) to identify the locations and contents of past toxic and hazardous-material disposal and spill sites, and to eliminate the hazards to public health in an environmentally responsible manner. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) is the federal law that addresses the identification, characterization, and releases of hazardous substances at such sites. The Installation Restoration Program (IRP) is the DOD program for conducting cleanups pursuant to CERCLA. Under the IRP, contamination resulting from past waste disposal is now being investigated at Hill AFB. The location of OU 4, which is one of the IRP sites and the subject of this report, is shown in figure ES-1. OU 4 includes landfills 1 and 2, the north gate dump sites, munitions dump, and spoils area.

A Preliminary Assessment, formerly known as Phase I, the Records Search, was done by Engineering Science during 1981 (Engineering Science, 1982). This study provided a history of landfill operations at Hill AFB and indicated that organic chemicals had not been disposed of in landfills 1 and 2, which make up part of the area that was later consolidated and identified as OU 4.

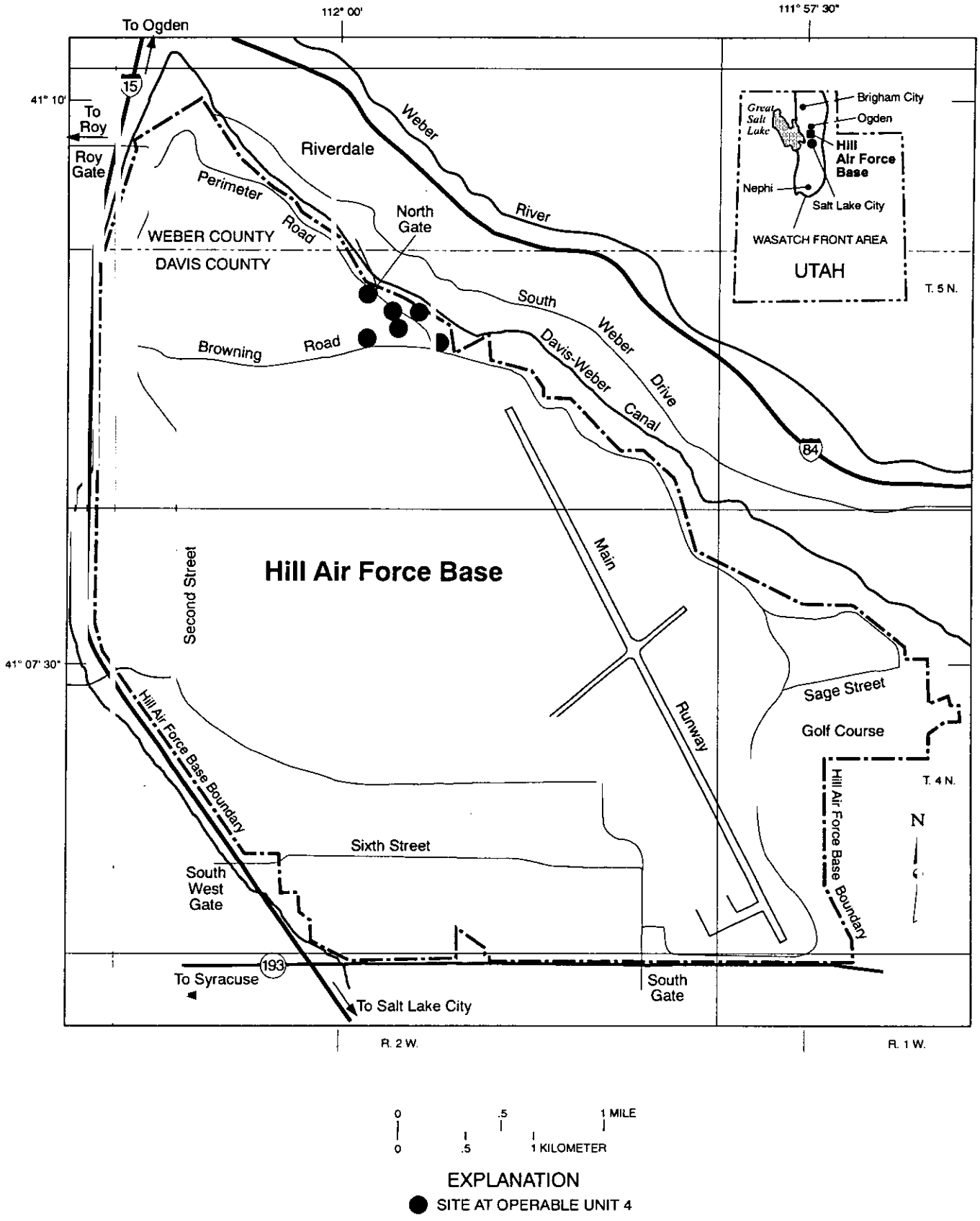


Figure ES-1.--Location of Operable Unit 4 at Hill Air Force Base. (Modified from Radian Corporation, 1988, figure 1.6-1.).

A Site Inspection, formerly known as Phase II, the Confirmation/Quantification Stage, was done by Radian Corp. from November 1985 to November 1987 (Radian Corp., 1988). Two monitoring wells were constructed downgradient from landfills 1 and 2, and one monitoring well was constructed upgradient from the landfills, in the shallow aquifer. Laboratory chemical analyses were done on water samples collected from the wells, and TCE was detected in both of the downgradient wells but was not detected in the upgradient well. The concentration of TCE in water from the well downgradient from landfill 1 was 4,185 ug/L; the concentration in water from the well downgradient from landfill 2 was 6.08 ug/L. The MCL for TCE in drinking water is 5.0 ug/L. The detection of TCE indicated that further investigation was necessary.

PURPOSE AND SCOPE OF THE INVESTIGATION

In September 1987, the U.S. Geological Survey began an investigation at OU 4. The primary objectives were to complete the scoping activities and characterize the site. Scoping activities completed were (1) collection of existing data about the site; (2) preliminary identification of site boundaries; (3) identification of potential Applicable or Relevant and Appropriate Requirements (ARARs); and (4) preparation of the Work Plan, Quality-Assurance Plan, and Health and Safety Plan.

During July 1988, the U.S. Geological Survey began an RI of contamination at OU 4. The objectives of the RI were to (1) characterize the extent of contamination; (2) determine the fate of contaminants; and (3) develop a baseline risk assessment for the potential exposure pathways through soil, ground water, and air.

Site-characterization activities completed as part of the RI were (1) definition of the landfill boundaries; (2) determination of vertical and horizontal hydraulic gradients; (3) determination of physical and hydrologic characteristics of sediments; (4) determination of extent of contamination; (5) determination of potential contaminant source areas; (6) determination of contaminant concentrations; and (7) identification of unidentified compounds reported in previous reports (Radian Corp., 1988, p. 4-244).

James M. Montgomery, Consulting Engineers, Inc. (JMM), conducted risk assessment studies during June 1989-91, working under a contract with Hill AFB. Using data gathered during the site characterization, JMM estimated current and future health risks posed by OU 4. The Baseline Risk Assessment is presented in Volume 2, dated November 1991.

Hill AFB is located in northern Utah, about 25 mi north of Salt Lake City and about 5 mi south of Ogden (fig. ES-1). Hill AFB covers about 6,700 acres and is located on the Weber Delta, a terrace about 300 ft above the valley floor in Weber and Davis Counties.

The landfills at OU 4 (fig. ES-2) are located along the top of a steep, terraced, north-facing escarpment that separates the Weber Delta from the Weber River valley. The Weber Delta consists of unconsolidated clay, silt, sand, and gravel.

Landfill 1 covers about 5 acres and is located in the northeastern part of Hill AFB. Mr. Joseph Fisher, former foreman of refuse collection, recalled that the landfill was about 25 ft deep. Available records indicate that few, if any, chemicals were disposed of in the landfill. Landfill 1 may have received waste from the Ogden Arsenal that could have included waste oils and solvents from a vehicle-maintenance facility (Radian Corp., 1988, p. 1-23).

Landfill 2 covers about 4 acres and is located about 900 ft northwest of landfill 1. Landfill 2 was operated between 1963 and 1965; general waste was dumped down the side of the hill and periodically burned. There are no records of chemicals being disposed of at this site.

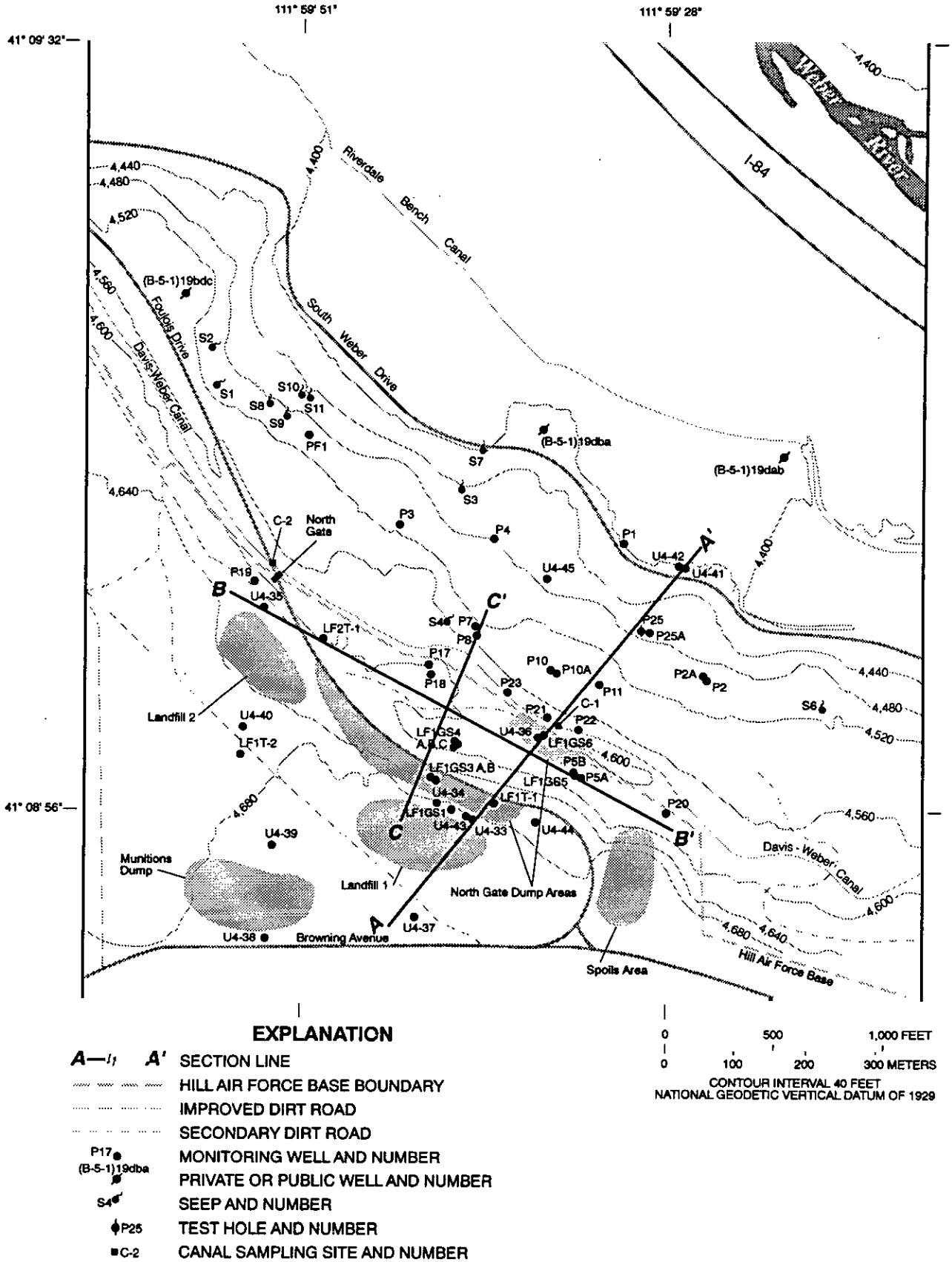


Figure ES-2.--Location of data-collection sites and sections in the area of Operable Unit 4.

The spoils area is located about 700 to 1,000 ft east of landfill 1 and at the east corner of the intersection of Browning Avenue and Foulois Drive. The spoils area has operated since 1972. Only solid waste is known to have been dumped at the site, but there is potential that some of the materials may have been contaminated with fuels from minor spills (Ed Heyse, Hill Air Force Base, oral commun., March 1991).

Suspected dump sites, referred to collectively as the north gate dump sites, are located along Foulois Drive southeast of the north gate and along the Hill AFB boundary northeast of Foulois Drive. There is no documentation of dumping at these sites, but it has been alleged that drums containing solvents and other material were disposed of during unauthorized dumping episodes at several sites along Perimeter Road (Radian Corp., 1990, p. 1-4). Perimeter Road intersects Foulois Drive near the north gate.

The munitions dump is located about 400 ft southwest of landfill 1 and was operated by the Ogden Arsenal as an above-ground storage area for munitions during World War II. Spent shell casings were observed in the area during site classification activities at OU 4.

FIELD PROGRAM

The seven major field activities done by the U.S. Geological Survey at Hill AFB as part of the RI at OU 4 included (1) an electromagnetic (EM) geophysical survey; (2) a borehole geophysical survey; (3) soil gas surveys; (4) installation of 42 monitoring wells; (5) collection and analysis of sediment and ground-water samples; (6) aquifer tests; and (7) regular measurement of water levels in monitoring wells. The field activities began in February 1988 and ended in August 1992. The data-collection sites are shown in figures ES-2 and ES-3.

SUMMARY OF RESULTS

Hill AFB overlies three aquifers (fig. ES-4). Two of the aquifers, the Sunset and the Delta, are productive sources of good-quality water and are used by both Hill AFB and surrounding communities. Water in these aquifers generally is confined and occurs at depths of 300 and 600 ft below the landfills. Shallow ground water, in which contamination has been detected, overlies the Sunset and Delta aquifers.

Drilling in the vicinity of OU 4 into the Provo and Alpine Formations has shown that the lithologic character of the deposits mainly consists of fines, which include silt and clay, with lesser quantities of silt and very fine sand (fig. ES-4). The lithologic character varies laterally and with depth, although not substantially in the first 60 ft.

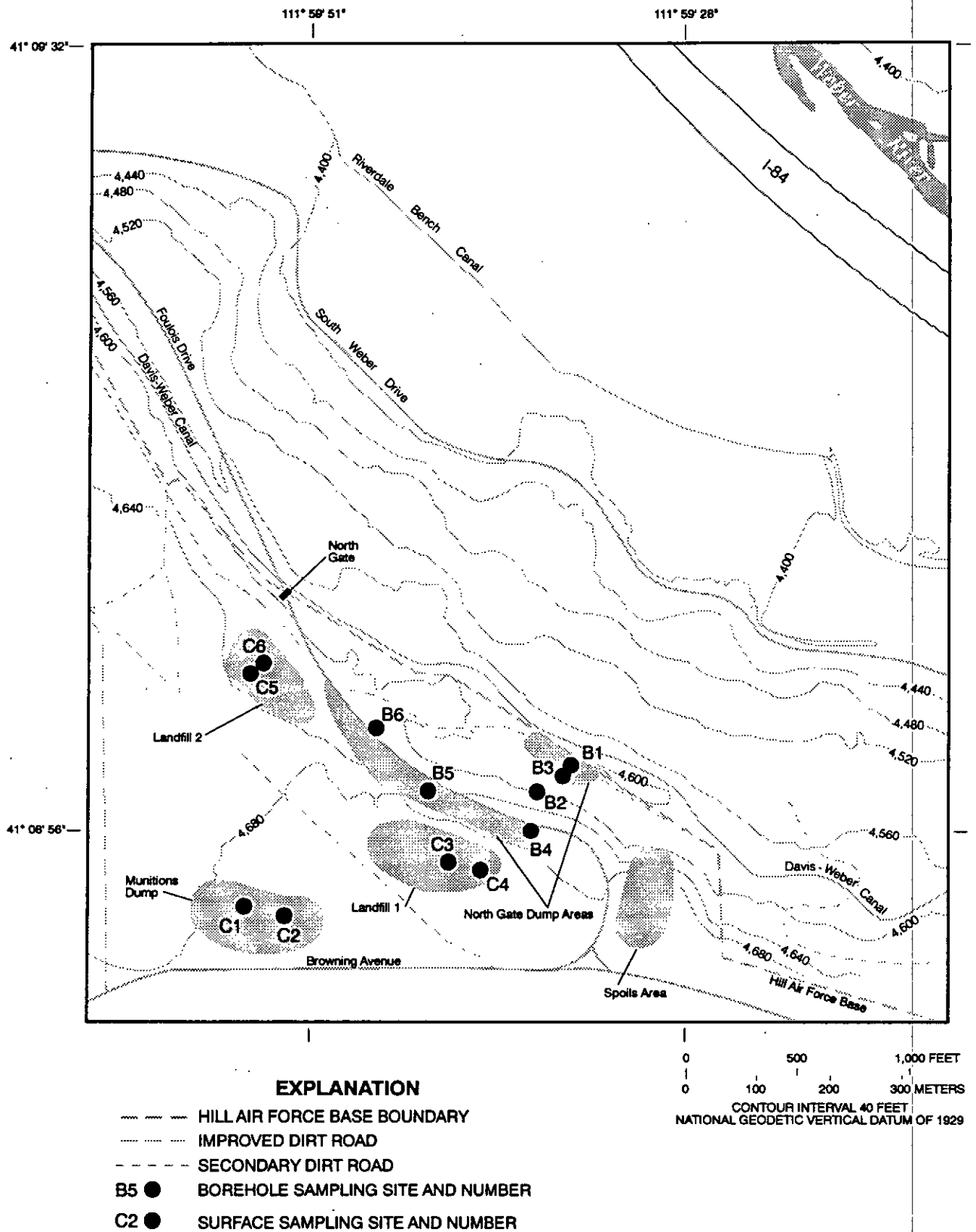


Figure ES-3.--Location of borehole and surface sediment sampling sites in the area of Operable Unit 4.

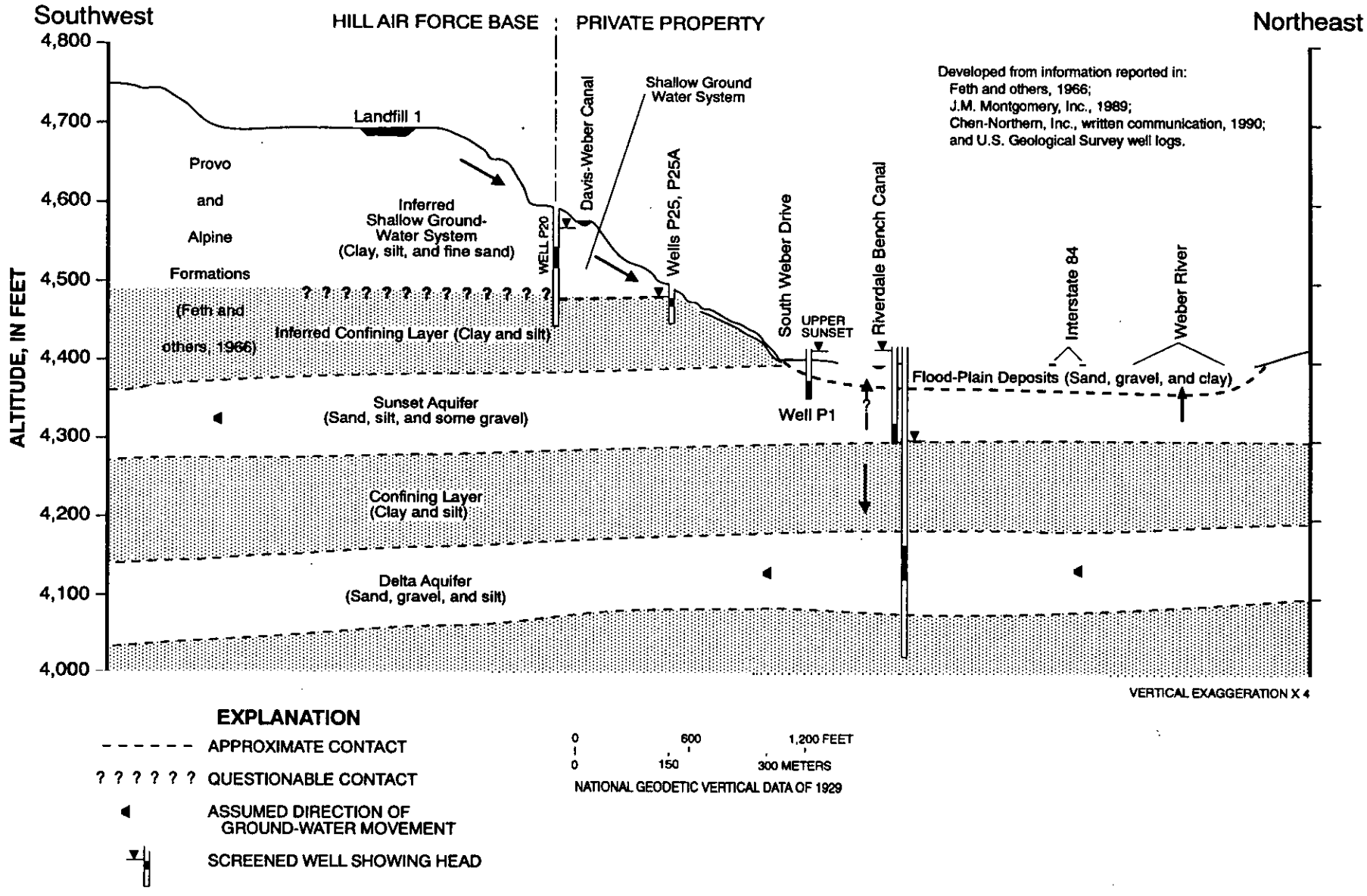


Figure ES-4.--Diagrammatic section of the probable relation between the shallow ground-water system in the area of Operable Unit 4, the flood-plain deposits of the Weber River, and the underlying regional confined aquifers.

The sediments of the shallow ground-water system are about 200 ft thick beneath the landfills and have been thinned, presumably by erosion, northeast of OU 4 near the hillsides immediately above South Weber Drive and the flood-plain deposits (fig. ES-4). Most ground-water movement near the landfills occurs in interfingered layers of sands and silts in the upper 30 to 60 ft of sediments. The upper part of the sediment, which includes sandy and silty material, is less than 20 ft thick along the hillsides.

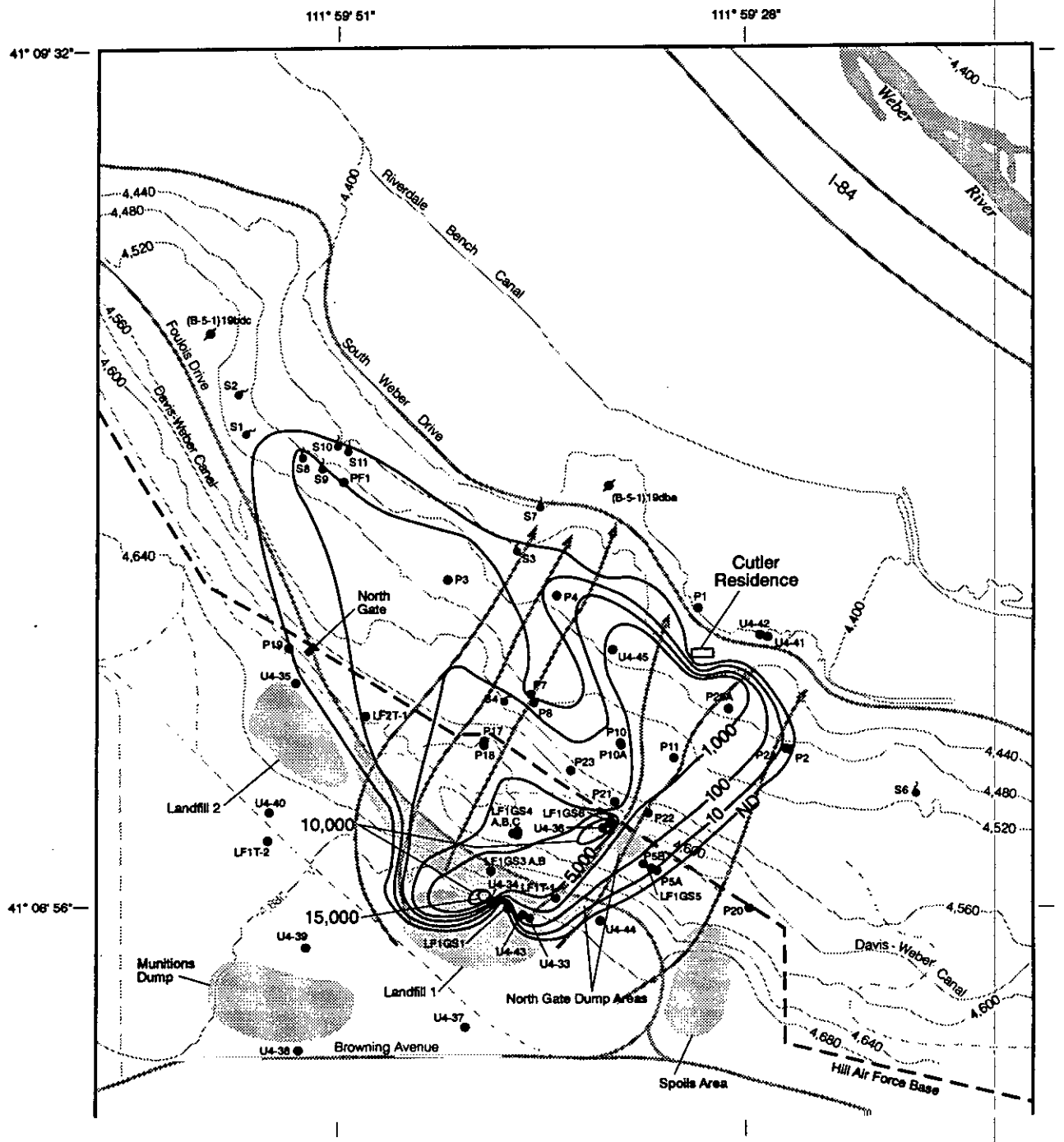
Discharge from the shallow ground-water system is primarily from seeps along the escarpments below the canal and at the base of the hillside. Some of this ground water probably subsequently infiltrates into the Weber River flood-plain deposits. Some ground water may flow from the confining layer that underlies the shallow ground-water system directly into the flood-plain deposits. Water from the shallow ground-water system subsequently mixes with water that has moved upward from the Sunset aquifer in the flood-plain deposits. Downward percolation through the thick sediments along the hillside is limited by horizontal layering and small vertical hydraulic-conductivity values.

Water from all wells was analyzed for VOCs and at least once for inorganic parameters; 13 VOCs and 2 inorganic contaminants were detected in water samples collected from monitoring wells and seeps. TCE was the VOC detected most frequently and in the highest concentrations.

Water from selected wells in and near suspected source areas was analyzed for semivolatile organic compounds, organochlorine pesticides, PCBs, chlorinated herbicides, and petroleum hydrocarbons; none were detected. Water from 32 wells, 1 seep, and 1 site on the Davis-Weber Canal was analyzed for trace elements and cyanide; 14 trace elements were detected.

Currently (September 1992), the Federal Safe Drinking Water Act (SDWA) has MCLs for nine of the VOCs: TCE, t-1,2-DCE, benzene, chloroform, 1,2-DCA, 1,1-DCE, PCE, toluene, and xylenes; and two inorganic compounds, nitrate and fluoride. Although SDWA has no MCL for sulfate, the State of Utah MCL applies. Comparison of the concentrations of observed contaminants to appropriate standards indicates that TCE exceeded the MCL in water from 20 monitoring wells and 3 seeps; benzene exceeded the MCL in 1 well; and 1,2-DCA, xylenes, sulfate, nitrate, and fluoride did not exceed the MCLs in water from any of the wells or seeps. Arsenic exceeded the MCL in water from two wells, nickel exceeded the MCL in water from two wells, and selenium in water from one well.

The most upgradient occurrence of TCE determined from chemical analyses of water occurred in water from wells U4-43 and U4-34, which are located along the downgradient edge (north side) of landfill 1 (fig. ES-5). Well U4-43 contained 440 ug/L and well U4-34 contained 18,000 ug/L of TCE. Because no TCE was detected upgradient from landfill 1 in well U4-37, the most probable source of TCE is landfill 1.



EXPLANATION

—100—	LINE OF EQUAL TRICHLOROETHYLENE (TCE) CONCENTRATION, 1986-92--Concentration in micrograms per liter. Interval is variable. "ND", not detected. Maximum contaminant level for TCE is 5 micrograms per liter. At sites with well clusters, the shallow well of the cluster was used
	GENERAL DIRECTION OF GROUND-WATER MOVEMENT
— — — —	HILL AIR FORCE BASE BOUNDARY
.....	IMPROVED DIRT ROAD
.....	SECONDARY DIRT ROAD
PF1	MONITORING WELL AND NUMBER
(B-5-1)19dba	PRIVATE OR PUBLIC WELL AND NUMBER
S4	SEEP AND NUMBER

0 500 1,000 FEET
0 100 200 300 METERS
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure ES–5.--Maximum concentrations of trichloroethylene in shallow ground water in the area of Operable Unit 4.

Trends of TCE concentration with time may indicate that the plume is migrating past some of the wells downgradient from landfill 1. As indicated by the histograms in figure ES-6, the concentrations of TCE in water from well LF1GS6 peaked in 1990 and began to decrease in 1991. The concentration of TCE in water from well LF1T-1 generally has been decreasing since sampling began in 1986. The higher concentrations of TCE that probably occurred soon after disposal in landfill 1 apparently have been flushed from landfill 1 and migrated past well LF1T-1 prior to when sampling began in 1986, and then passed well LF1GS6 in 1990. If this interpretation is correct, the concentration of TCE in water from well U4-43 would be expected to decrease and the decreasing trends in well LF1T-1 and LF1GS6 would likely continue.

The largest concentration of TCE outside the Hill AFB boundary extends north from well LF1GS6. A tongue of the plume that contains between 1,000 and 5,000 µg/L extended downgradient about 1,000 ft from well LF1GS6, to South Weber Drive. Inside the boundary of Hill AFB, the maximum concentration of TCE in ground water was 18,000 µg/L, and outside the boundary, the maximum was 2,800 µg/L. The contaminated area inside the boundary of Hill AFB is about 18.5 acres; outside the boundary it is about 44 acres.

About 87 percent of the TCE in the water fraction of the subsurface is present in water with a TCE concentration that exceeds 1,000 µg/L and represents about 34 percent of the total volume of contaminated water. The total weight of TCE in the contaminated water is about 1,400 lbs, or about 113 gal of pure TCE product. If equilibrium conditions exist, then 240 gal of TCE are sorbed to the contaminated soil fraction of the subsurface. The total volume of TCE in the subsurface was computed to be 353 gal.

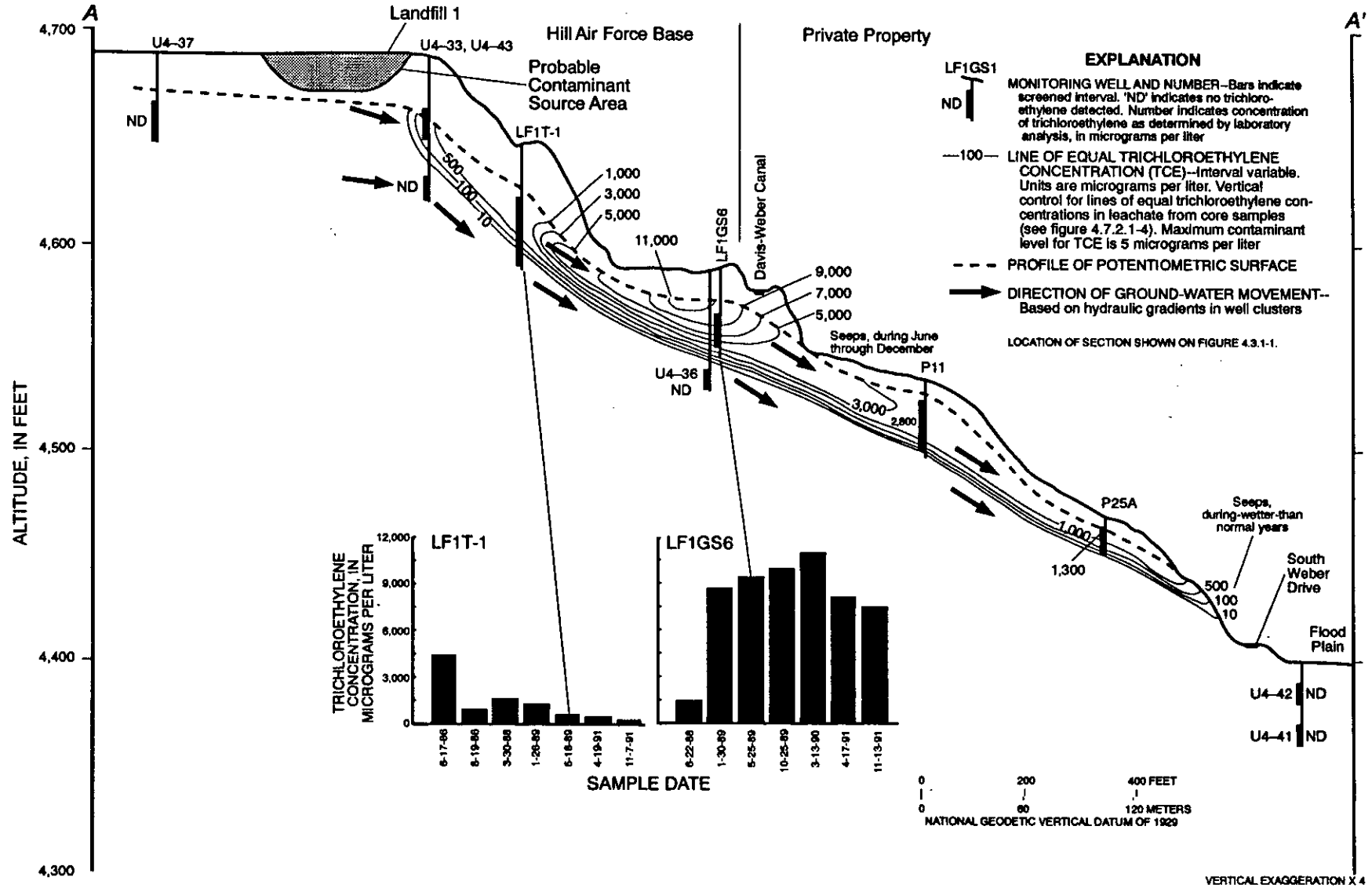


Figure ES-6.--Vertical, lateral, and temporal variations of trichloroethylene concentration in ground water along section *A-A'*, 1986-92, in the area of Operable Unit 4.

Hydraulic-head and chemical data from a well along the downgradient edge of landfill 1 and from clusters of wells at four sites downgradient from landfill 1 were used to construct an approximate flow path for contaminant migration (fig. ES-7). Along this approximate flow path, TCE apparently seeps from landfill 1 into the shallow ground water near site U4-34, migrates downgradient into the saturated zones of wells LF1GS3B, LF1GS4B, LF1GS4C, and P18, and discharges along the downgradient side of the canal bank at seep S4. Some ground water is lost by evapotranspiration along the bank, and TCE does not reach the cluster of wells, P7 and P8.

A surface sediment sample from landfill 1 contained 67.3 mg/kg of lead, which is about 6 to 10 times greater than occurred in other sediment samples either upgradient or downgradient from the landfill. Although lead was present in this sample at relatively high concentrations, it has not been found as a contaminant in the water downgradient from the landfill.

Evaluations of data collected during 1992 confirmed that landfill 2 and the munitions dump were not source areas of TCE or other contaminants. Extensive analytical tests were made in the previously suspected north dump areas to determine if contaminants other than TCE were present in the sediments from the unsaturated zone. No other contaminants were detected. Concentration gradients of TCE in the unsaturated zone in these areas indicate that the TCE was derived from contaminated ground water that has migrated downgradient from landfill 1; thus, the north gate dump areas are no longer suspected of being source areas of the TCE contamination.

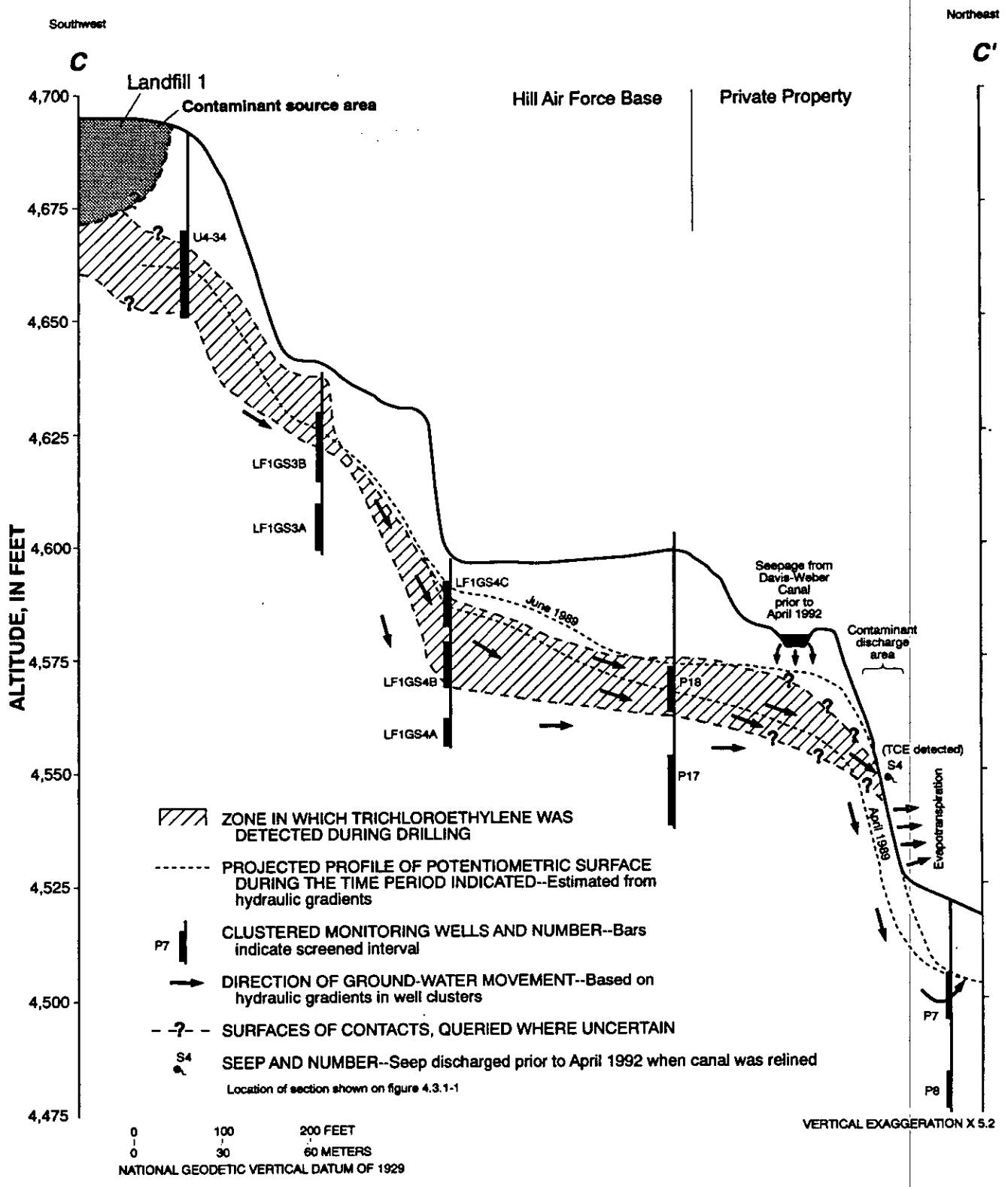


Figure ES-7.--Approximate movement of trichloroethylene along section *C-C'* from probable contaminant source to discharge location in the area of Operable Unit 4.

Data available as of November 1991 did not indicate that there were any complete exposure pathways that presented any significant health risk to people living or working in the vicinity of OU 4; however, more data need to be collected to adequately determine the risk associated with inhaling indoor air. The data also indicated that there was little potential for ecological harm to result from the contaminants present at OU 4. Human health risk associated with the occurrence of TCE, however, could develop in the future. TCE concentrations in the shallow ground water are high near the source area at Hill AFB and near the Cutler residence, and could present a potential health risk should someone use this water for general domestic purposes such as drinking and showering. Some of the shallow ground water is used for irrigation, but currently (1992), none is used for domestic purposes. Thus, the risk assessment scenarios presented for domestic use are hypothetical situations that could occur if the water is used in the future.

Surface water near OU 4 includes water diverted from the Weber River into the Davis-Weber Canal and ground water that discharges from seeps between the canal and South Weber Drive. No contaminants have been detected in the Davis-Weber Canal; however, VOCs, including TCE, have been detected in water from some of the seeps. Environmental receptors have the greatest potential to be exposed through this media, including wild and domestic animals, and crops. Because VOCs volatilize when exposed to air, this potential exposure route is unlikely to be significant. Data that indicate that TCE can be stored in plant and animal tissue, however, is currently being investigated (Steve Glaser, J.M. Montgomery, Consulting Engineers, Inc., oral commun., 1993).

The probability of an individual getting cancer by using water from the shallow ground-water system in the most contaminated area near well LF1GS6, by drinking water and taking a daily shower for a period of 30 years, was estimated to be equal to 7 in 1,000 (a cancer risk of 7×10^{-3}). This risk is greater than the 1×10^{-4} to 1×10^{-6} range that comprises the minimum level of risk that EPA considers to be significant. Near well P25A, a cancer risk was estimated to be 1×10^{-3}. The hazard index for the most contaminated area near well LF1GS6 was estimated to be 50, which is also significant, because hazard indices greater than 1 indicate that noncancerous health effects may be a significant possibility. This hazard index is even more significant since inhalation exposure was not included in the calculation because of the lack of a reference dose for TCE. A hazard index of 6 was estimated for the area near well P25A.

The shallow ground-water system terminates, primarily as a result of erosion, above the clay layer along the hillside southwest of the Weber River flood plain. Water from the shallow ground-water system reaches the flood-plain deposits either by discharging from seeps at the base of the hillside and then infiltrating into the flood-plain deposits, or as ground-water inflow through the predominantly clay layers just beneath the shallow ground-water system. This water then mixes with, and probably is diluted by, water in the flood-plain deposits (some of which probably has moved upward from the upper part of the Sunset aquifer). The markedly different inorganic-chemical compositions of water from the shallow ground-water system and from the flood-plain deposits indicates that the two systems are either isolated or significant dilution is occurring. In either case, there is apparently little potential for the Weber River to be affected by contaminants from OU 4.

There are currently no significant exposures resulting from TCE in outdoor air. It is unlikely that this situation will change in the future. There is inadequate data to assess current risks with respect to inhaling TCE in indoor air, and additional air monitoring is recommended. TCE was detected during a soil-gas survey conducted in the immediate vicinity of the Cutler residence, although the concentrations of TCE were very close to the detection limits. If the plume of contamination has migrated beneath the Cutler basement, there would be a potential for TCE vapors to migrate into the basement and create a risk. The presence of the high TCE concentrations in ground water 100 ft upgradient from the house, the presence of a small hole in the basement floor, and the fact that people probably spend a few hours per day in this basement are a strong indication that this pathway could pose a health risk in the future.

RECOMMENDATIONS

A monitoring program was part of the recommendations presented on pages 6-18 to 6-20 of volume 1 (June, 1992), and monitoring has been in effect since March 1991. Evaluations, based on the data collected during 1992 and presented in this report, indicate a need to revise the monitoring program. Some of the wells drilled during 1992 need to be included in the monitoring program, and some of the previously monitored wells (fig. ES-8) need to be discontinued.

Water samples need to be collected twice a year from 20 wells and annually from 4 wells that are listed in table ES-2 and analyzed according to the schedule shown in table ES-3, to monitor spatial and temporal changes in the inorganic and organic chemistry of the ground water. After each round of monitoring, the analytical results need to be reviewed to determine if changes have occurred that might necessitate revision of the monitoring program.

Prior to April 1992, a large percentage of ground-water recharge to the area downgradient from the Davis-Weber Canal originated from canal leakage. During February to April 1992, the cracked and broken concrete lining in the Davis-Weber Canal was replaced in the reach that crosses OU 4; presumably, the canal will no longer leak. With no leakage, the reduced recharge to the downgradient area likely would affect seasonal variations in water levels. To evaluate the effect of reduced recharge on seasonal fluctuations of water levels, the frequency of measurement would need to be every two months.

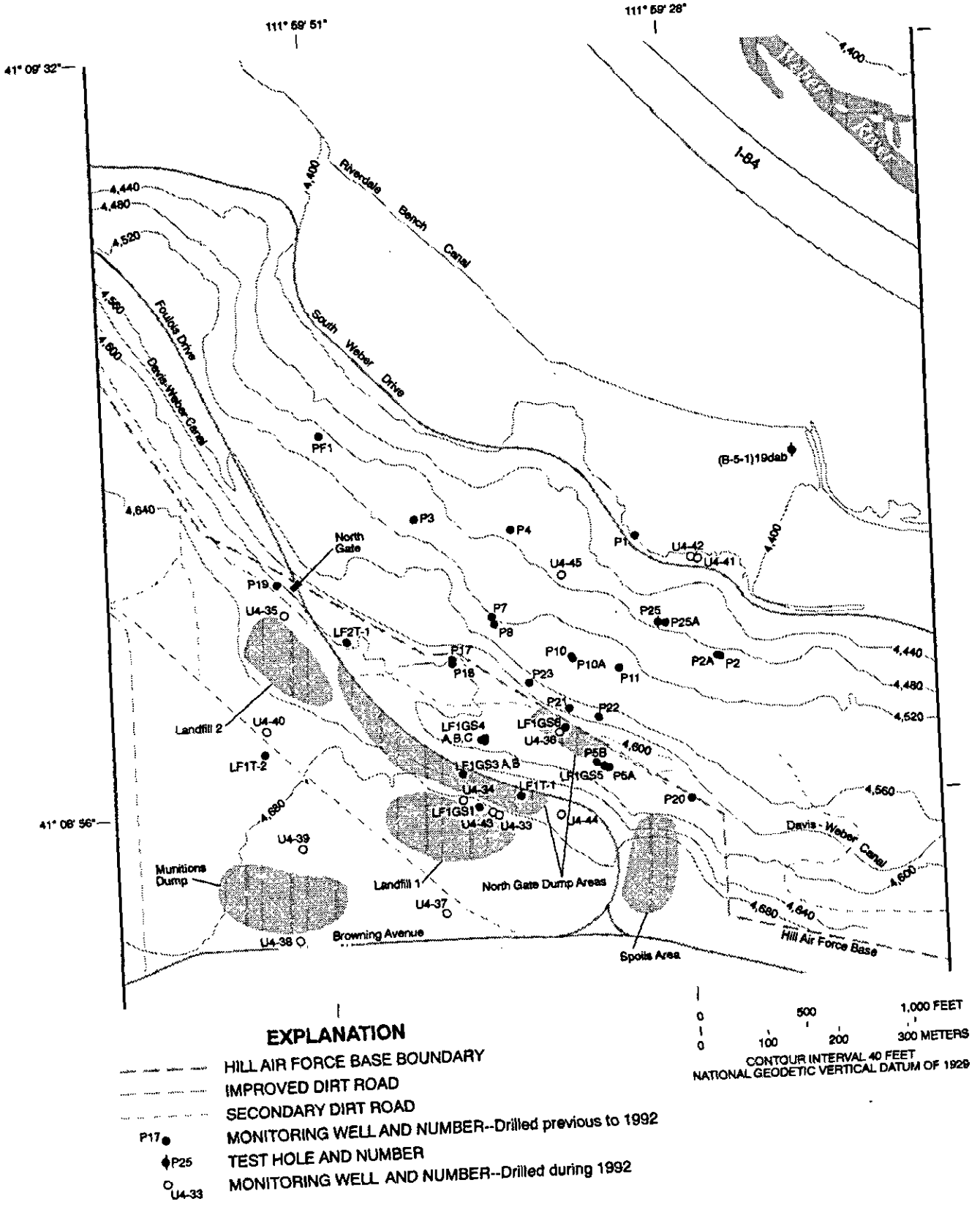


Figure ES-8.--Location of monitoring wells and test holes in the area of Operable Unit 4.

Table ES-2 Wells recommended for continued monitoring of water quality at semiannual or annual intervals and water levels at 2-month intervals in the area of Operable Unit 4.

Well number
LF1T-1
LF2T-1
LF1GS3A
LF1GS3B
LF1GS4A
LF1GS4B
LF1GS6
P1
P2 (annual)
P2A (annual)
P3
P4
P5A (annual)
P5B (annual)
P11
P25A
(B-5-1)19bdc
U4-33
U4-34
U4-35 (metals only)
U4-36
U4-37 (water level only)
U4-41
U4-42
U4-43

Table ES-3 Chemical parameters, analytical methods, and number and type of analyses for monitoring wells in the area of Operable Unit 4

[--, no sample will be collected]

Parameter	Analytical method[1]	Number of well samples	Number of blind duplicates	Number of trip blanks	Total
Water Samples					
Volatile organic compounds	SW8240	23	2	2	27
Common Anions	A429	23	2	--	25
Alkalinity	A403				
Nitrate + nitrite	E353.2	23	2	--	25
Metals	SW6020	24	2	--	26

[1] Analytical Method References

SW Methods — Test Methods for Evaluating Solid Waste, Laboratory Manual: Physical/Chemical Methods, SW-846, 3rd ed. (U.S. Environmental Protection Agency, 1986).

A Methods — Standard Methods for the Examination of Water and Wastewater, 16th ed. (American Public Health Association, 1985).

E Method — Methods for Chemical Analysis of Water and Wastes, EPA Manual 600-4-79-020 (U.S. Environmental Protection Agency, 1983).